

**The Narwhal (Monodon monoceros L.)
Harvest in Pond Inlet, Northwest
Territories: Hunt Documentation and
Biological Sampling, 1982-1983**

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March 1988

**Canadian Manuscript Report of
Fisheries and Aquatic Sciences
No. 1975**

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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This is the 6th Manuscript Report
from the Central and Arctic Region, Winnipeg

ERRATA

Weaver, P.A., and R.W. Walker. 1988. The narwhal (*Monodon monoceros* L.) harvest in Pond Inlet, Northwest Territories: hunt documentation and biological sampling, 1982-1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1975: iv + 26 p.

1. Page 6, Col. 1, Para. 5: Delete phrase "(hereinafter referred to as revised estimators)".
2. Page 19: Caption should read "Table 13. Significant relationships among body and intact tusk measurements from known length narwhal samples in Pond Inlet, NWT, 1982-1983."

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Cat. No. Fs 97-4/1975E

ISSN 0706-6473

Correct citation for this publication is:

Weaver, P.A., and R.W. Walker. 1988. The narwhal (*Monodon monoceros* L.) harvest in Pond Inlet, Northwest Territories: hunt documentation and biological sampling, 1982-1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1975: iv + 26 p.

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ABSTRACT

Weaver, P.A., and R.W. Walker. 1988. The narwhal (*Monodon monoceros* L.) harvest in Pond Inlet, Northwest Territories: hunt documentation and biological sampling, 1982-1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1975: iv + 26 p.

This report presents a harvest analysis for the 1982 and 1983 narwhal (*Monodon monoceros*) hunts in Pond Inlet, NWT. We describe the composition and distribution of the landed catch, provide loss rates for each hunt phase, and estimate the annual total kill. Loss rates are reported as a percentage of the total number of narwhal struck. Losses at the floe edge were 56% and 27% in 1982 and 1983 respectively. During the ice crack hunts, losses were 56% in 1982 and 12% in 1983. The 1982 open water hunt was separated into deep and shallow water hunting phases; the combined loss rate for these two phases was 42% of the total number struck. We estimate that 169 narwhal were killed in 1982 and that 193 narwhal were killed in 1983. Biological information collected during both years included measurements of body and tusk dimensions, blubber thickness, reproductive organs, and qualitative observations of stomach contents. These data are included as a contribution to the data base for narwhal frequenting northern Baffin Island.

Key words: Arctic; marine mammals; Monodontidae; harvest analysis; morphology; reproduction.

RÉSUMÉ

Weaver, P.A., and R.W. Walker. 1988. The narwhal (*Monodon monoceros* L.) harvest in Pond Inlet, Northwest Territories: hunt documentation and biological sampling, 1982-1983. Can. Manuscr. Rep. Fish. Aquat. Sci. 1975: iv + 26 p.

Ce rapport présente une analyse des récoltes de narvals (*Monodon monoceros*) obtenues durant des chasses observées à Pond Inlet, NWT en 1982 et 1983. Nous y décrivons la composition et la distribution des récoltes et le taux de perte de chaque type de chasse, et nous y estimons le nombre total des narvals morts. Le taux de perte est comme pourcentage de la nombre total des narvals atteints de balles. Au bord de la banquise, le taux de pertes était 56 p 100 en 1982 et 27 p 100 en 1983. Dans les failles de la banquise la chasse a causé un taux de perte de 56 p 100 en 1982 et de 12 p 100 en 1983. La chasse en eau libre en 1982 est divisé en deux phases, une phase en eau profonde et une phase en eau peu profonde. Le taux de perte pour ces deux périodes était 42 p 100 du nombre total atteint de balles. Les informations biologiques prises pendant les deux années comprenant les mensurations du corps et de la défense, des gonades, l'épaisseur du panicule, et des observations qualitatives sur les contenus stomachaux. Celles-ci sont inclus comme contribution à la base des données sur les narvals qui fréquentent le nord de la terre de Baffin.

Mots-clés: arctique; mammifères marins; monodontidae; analyse des récoltes; mensurations du corps; reproduction.

INTRODUCTION

Summering concentrations of narwhals (*Monodon monoceros* L.) regularly occur in the inshore waters of northern Baffin Island. These whales are a traditional Inuit resource, and continue to occupy a prominent place in the social fabric and economy of settlements in the region. On the north Baffin coast, narwhals are hunted in the waters of Navy Board Inlet, Eclipse Sound and Pond Inlet by residents of Pond Inlet, and in Admiralty Inlet by the residents of Arctic Bay. Each of these settlements has an annual quota of 100 narwhals.

The population status and management of narwhals have been subjects of major concern over the past decade. In 1977, annual harvest quotas based on local requirements and limited biological information were negotiated with narwhal hunting communities. This regulated harvest is an attempt to protect narwhal stocks until sufficient biological information is available to develop a sound management strategy. The quota system requires that an identification tag be affixed to all landed narwhals. The tag requirement is useful to assess the annual landed catch of animals, but it does not supply information on hunting losses, and in some communities it does not ensure that all female narwhals killed are reported (Finley and Miller 1982; DFO unpublished).

Narwhals summering in Eclipse Sound have been the subject of a number of studies since the inception of the quota system. Descriptions of narwhal social structure and behaviour (Silverman 1979; Silverman and Dunbar 1980); catch history (Mitchell and Reeves 1981) and hunting regulations (Kemper 1980); hunting techniques and harvest analysis for 1976-79 (Kemper 1980; Finley et al. 1980; Finley and Miller 1982); alternative hunting techniques and economics (Finley and Miller 1982); and narwhal summer diet (Finley and Gibb 1982) are available. Hay (1984) documented the life history and basic biology of narwhal frequenting the coastal waters of northern Baffin Island.

In 1982 and 1983, staff of the Central and Arctic Region of the Department of Fisheries and Oceans (DFO) observed the narwhal harvest in Pond Inlet, NWT (Fig. 1). The objectives of the study were to prepare a detailed harvest analysis for the two years of study, to update information on narwhal hunting techniques, and to collect biological samples from landed whales. This report summarizes the observations, and compares the 1982-1983 harvest analysis with earlier studies. We discuss variations to previously described hunting techniques where applicable. The results of the biological sampling program are included as a contribution to the existing data base for narwhal frequenting northern Baffin Island.

MATERIALS AND METHODS

HUNT AND DOCUMENTATION

DFO staff accompanied Pond Inlet narwhal hunters from 12 June-25 August in 1982 and from

18 June-22 July in 1983, to observe all phases of the annual harvest in Pond Inlet and Eclipse Sound. A resident hunter was contracted to provide additional information on hunting activity prior to staff arrival and after their departure.

In documenting the harvest, the term "hunting event" represents the action of taking aim at target narwhals by one or more hunters. Hunting events were either: directly observed, recorded through hunter interviews conducted by DFO personnel, recorded by the contract observer after radio conversations with hunters in other areas, or recorded by the contract observer for hunts conducted before and after our field season. When more than one whale was reported (but not observed) landed, a separate hunting event has been assumed for each. Rifle calibre, projectile type, firing range, and narwhal pod size and composition were noted whenever possible. DFO field staff interpreted observed woundings in consultation with the hunters, by considering the bullet(s) angle of incidence, the firing range, location of the hit and the target animal's behaviour.

Narwhals struck in each hunting event were recorded as landed, mortally wounded, superficially wounded, or sunk/lost. Interpreting the extent of an animal's injury is subjective, but interpretation can be made more realistic by strict definition of each category. The criteria for determining the lethality of wounds sustained by target narwhals are similar to those described by Finley and Miller (1982).

"Mortal" wounds fell within a lethal window bounded by the eye and a point 40 cm behind the flipper, and resulted from shots fired at an angle that placed the bullet near the spine or the base of the skull. Close range hits to the pleural cavity or to the abdomen were also considered mortal. The lethal firing range was considered to be within 25 m at sea level, although ranges exceeding 25 m were also considered lethal if shots were fired from an elevated position, such as from rafted ice or from shore.

Shallow, or low angle hits to the dorsal surface were classed as superficial wounds. The low angle of incidence should allow bullet penetration of only the blubber or the most distal muscle layers, and many narwhals carry scars of this type. Superficial wounds are generally inflicted from distances exceeding 25 m and from shots fired at partly submerged whales.

In some cases killed narwhal are not retrieved, either because they sink soon after death, or because they are beyond retrieval range. Retrieval range is reduced at the floe edge if the hunter has no boat, and during early breakup when drifting ice hampers navigation. DFO staff recorded sinking losses, however contract observer records often refer to "lost" whales, or those that "did not die". Target narwhal fitting any of these descriptions were classified as sunk/lost, since observer descriptions give no indication of the severity of wounding. We prefer to err on the conservative side, rather than underestimate sinking loss.

BIOLOGICAL SAMPLING

Each landed whale examined was assigned a unique catalogue number, and field staff recorded standard measurements (Norris 1961) on prepared information forms. The contract observer used data sheets printed in Inuktitut, from which the information was later translated into English. All measurements were recorded to the nearest centimeter. We used total length over 340 cm in females and over 390 cm in males as an index to maturity when describing the composition of the landed catch (Finley and Miller 1982; Finley and Gibb 1982; Hay 1984). Tusk dimensions (exposed and total length, basal circumference) were recorded from landed whales examined and from tagged tusks available in the settlement.

Muktuk (dermis and epidermis) and blubber (hypodermis) thickness were measured in millimeters at mid-dorsal, -ventral and -lateral locations along the axillary and umbilical circumferences, when circumstances permitted.

Field staff collected reproductive organs from landed narwhal whenever possible. Testes were measured in three axis (length, width and height) and the presence of seminal fluid was recorded. Testis volume was later calculated as the cross product of the three measurements. In 1983 testes were weighed (exclusive of epididymis) using a 2 kg capacity spring scale (Chatillon, N.Y., Model IN-2). Testes and associated epididymis were then fixed in 10% formalin solution.

Females were palpated for evidence of lactation, and the quantity and description of milk was recorded. When possible mammary glands were exposed, sagittally sectioned and the midpoint thickness recorded. The uterus was removed and examined for the presence of a fetus. Ovaries were preserved in 10% formalin solution. Fetal position within the uterus was recorded prior to removal. Near- or full-term fetuses were assigned a catalogue number and sampled as adults. Small fetuses were sexed, measured and either frozen or fixed in 10% formalin.

Stomach contents were examined in the field, and representative foods were coarsely identified as fish, squid, or invertebrates. Prevalent items were noted and the volume of total stomach contents was estimated.

Data analysis was performed using the Statistical Analysis System (1982), on an Amdahl 5850 computer. The critical level for tests was set at 0.05.

RESULTS AND DISCUSSION

HUNT DOCUMENTATION

Changing ice conditions divide the annual harvest into three major phases: the floe edge, ice crack and open water hunts (see Finley et al. 1980; Kemper 1980; Finley and Miller 1982). These hunts are usually conducted from outpost

camps (Fig. 1), although some are conducted from the settlement during the open water season.

Information obtained through hunter interview, HF radio communications and contract observer records complements that gathered during directly-observed hunting events, and provides a more complete record of hunting activity. Variations to previously described ice crack and open water hunting techniques are discussed in their respective sections below.

The floe edge hunt

The first phase of the narwhal hunt occurs while the landfast ice is still solid and extends into Lancaster Sound and Baffin Bay. Narwhals congregate at these landfast ice (floe) edges awaiting access to their summering area in Eclipse Sound.

The floe edge hunt is limited by local weather and ice conditions, distance from the community, and by the number of tags allotted to this hunt phase by the local Hunters and Trappers Association (HTA). In 1982, the Pond Inlet floe edge was 5 h by snowmobile from the settlement; and in 1983, poor ice conditions increased travel time to almost 18 h (Fig. 1). The Navy Board Inlet floe edge hunt occurs concurrently but was not monitored. Techniques used by Pond Inlet narwhal hunters during the 1982 and 1983 floe edge hunts are unchanged from those described by Finley et al. (1980); Kemper (1980); and Finley and Miller (1982).

1982: Narwhals were first seen at the floe edge on 24 May 1982 and the first successful hunt took place on 02 June (from contract observer records). DFO field staff observed the floe edge hunt from 12 June until 02 July, when the hunters returned to the settlement. Shots were fired during 12 of 15 observed hunting events, from a mean range of 43 m. Whales were observed struck in eight of these events, from a mean range of 25 m (Table 1). Of the nine whales observed struck, two were landed, four were mortally wounded, two were superficially wounded, and one narwhal was wounded to an undetermined extent (Table 2). Both landed narwhals were mature females, based on total length (Table 3).

Information on 38 hunting events is available from all sources (DFO, contract observer records and hunter interviews). Shots were fired in 35 events from a mean range of 37 m. Thirty-two whales were struck in 31 events from a mean range of 22 m (Table 1). Of these, 18 were landed, four were mortally wounded, two were superficially wounded and eight were reported sunk/lost (Table 2). The total recorded landed catch included two males, twelve females and four whales of undetermined sex (of which three were tusked). Five mature females were examined, of which two carried term fetuses (Table 3).

1983: The Pond Inlet HTA limited the floe edge hunt to 10 animals in 1983, due to the high losses incurred the previous year. The first narwhal was taken on 30 May and this phase of the harvest continued until 04 July. Shots were fired in 17 of 19 observed hunting events from a

mean range of 17 m and whales were struck in 11 events from a mean range of 13 m (Table 1). Of eleven whales observed struck, four were landed, two were mortally wounded, four were superficially wounded and one was sunk (Table 2). All four landed narwhals were mature tusked males (Table 3).

Available information from all sources yields a total of 32 hunting events. Twenty-three whales were struck in 30 of these events, from a mean range of 13 m (Table 1). Of 23 whales struck, seven were landed, two were mortally wounded, four were superficially wounded and 10 were sunk/lost (Table 2). The landed catch consisted of six males and one female. Five of the six males were tusked and are considered mature. The female was reported landed on 30 May, prior to data collection, and its length was not recorded (Table 3).

A floe edge hunt occurs simultaneously at Navy Board Inlet, from which two narwhals were recorded landed in 1983 by a party of four hunters.

The ice crack hunt

Ice conditions begin to deteriorate in early July; cracks form across the inlets and fiords and melt holes (often seal holes enlarged by drainage) appear. The landfast ice eventually separates from the shore and disperses. Narwhals penetrate into Eclipse Sound, moving along the cracks and under the ice from opening to opening. Changing winds affect crack widths, which during this study varied from 3 to 200 m. Hunting at ice cracks continues until melting renders travel unsafe. In 1982, poor ice conditions restricted travel and most hunting occurred directly offshore from Sadliarusiq outpost camp (Fig. 1). The ice was more solid in 1983 allowing hunters to use cracks within 3 km of Sadliarusiq.

Finley et al. (1980) reported the increased vulnerability of narwhals to hunting during the ice crack hunt, and our observations collected during this study support their conclusion. In addition to the ice crack hunting technique described by these authors, whales were sometimes shot from cliffs overlooking the ice cracks. At Sadliarusiq outpost camp, 30 m high cliffs were used as a hunting platform.

1982: When DFO staff arrived at Sadliarusiq with four local hunters on 07 July, eight hunters and their families had already set up tents, and one family was camped nearby. There were no hunters left at the Pond Inlet floe edge. Poor weather and ice conditions restricted hunting activity, and on 09 July all but four hunters returned to Pond Inlet. Narwhal hunting at the ice cracks began on 10 July and continued until the ice broke on 16 July.

Tables 1 and 2 contain summary information for the 1982 ice crack hunt. Shots were fired during five of six observed hunting events at a mean range of 56 m. Narwhals were struck in three observed events, but the range (15-20 m) is known for only one (Table 1). Of three animals struck, none were landed, two were mortally wounded and one was lost (Table 2).

Twelve hunting events were recorded from all sources, and shots were fired in 11 of these, at a mean range of 35 m. Narwhals were struck in nine events, at a mean range of 8 m (Table 1). Four whales were landed, two were mortally wounded and three were sunk/lost (Table 2). The total recorded landed catch consisted of one mature male, two females and one tusked animal of unrecorded sex. The tusked animal is considered immature, since its' tusk was reportedly <30 cm in length. Only one of the landed females was examined but since it had been butchered a length measurement was not obtained (Table 3).

1983: Three families were camped at Sadliarusiq when field staff arrived on 09 July, and two hunters were camped at an ice crack 3 km away. On 10 July, 10 additional hunters arrived from the floe edge since the ice was beginning to break. The first hunt was observed the next day. By 15 July 5-7 hunters remained at Sadliarusiq, and hunting continued until the ice broke on 20 July.

Shots were fired during all 14 observed hunting events, from a mean range of 18 m. Ten narwhals were struck in nine of these events, from a mean range of 8 m (Table 1). Of the 10 whales observed struck, seven were landed, two were superficially wounded and one was lost (Table 2). The landed catch consisted of six mature tusked males and one pregnant female (Table 3).

Twenty-nine hunting events were recorded from all sources, and shots were fired from a mean range of 17 m. Narwhals were struck in 24 of these events, from a mean range of 9 m (Table 1). Of 25 whales struck, 19 were landed, three were superficially wounded and three were sunk/lost (Table 2). The total recorded landed catch of 19 narwhals includes 10 males. Data are available for eight mature tusked males. Two mature females were examined, one of which was carrying a full term fetus. Two untusked whales and five whales of unrecorded sex were reported killed; and in addition, one dead female was found on 11 July (Table 3).

The open water hunt

Previous accounts of open water hunting incorporate all hunting events which occur after breakup. We prefer to divide this hunt phase into two distinct periods. The first, characterized by deep water hunting, occurs after breakup and during ice dispersal in late July. The second period, characterized by shallow water hunting, begins after ice dispersal in early August and continues until the quota is filled or until narwhals have migrated from the area.

During ice dispersal, hunting is conducted from small boats and hunters may wait on ice pans for narwhals to pass. When ice conditions prevent hunting from boats, hunters at Sadliarusiq use the nearby cliffs as a hunting platform, positioning themselves at approximately 30 m ASL. Shots are fired seaward of passing narwhal to drive them closer to shore, where they are killed. The hunters then retrieve the carcasses using small boats. Many whales are

wounded in this first phase of the open water hunt (see section on Loss Rates).

When the water becomes clearer of ice, hunters hunt from boats and often cooperate, using several boats to drive the narwhals inshore. Shots are fired over the whales to direct their movement, sometimes from shore, before the boat chase begins. Harpoons are used to secure wounded and dead animals, and in some cases dead whales are attached to a float and left adrift while the hunt continues. On occasions where narwhals could be closely approached, harpoons were used before the narwhals were shot, reducing the possibility of losing the whale.

Hunting by boat is the most effective method for reducing losses. Herding whales to shallow areas allows better selection by the hunters; harpoons and floats may be used effectively; and sinking losses are reduced since most sunk whales can be retrieved with grappling hooks and line. Whales were landed in four of the five events in which a harpoon and float were used; on one occasion the narwhal dove and swam off with the hunter's gear. Narwhals which are struck in shallow water but not secured can sometimes be pursued and captured. In contrast, few successful deep water hunts were observed; this technique usually resulted in wasted ammunition and lost whales.

1982: From 18 to 26 July, the number of hunters present at Sadliarusiq varied between five and seven. Field staff observed 15 hunting events, the majority of which were conducted from nearby cliffs. The mean firing range for observed hunting events was 165 m; and narwhals were struck in eight of these, from a mean range of 138 m (Table 1). Three whales were observed landed, three were mortally wounded and two were superficially wounded (Table 2). The landed catch consisted of one mature male and two mature females. Two dead whales (one of each sex) were found at the end of July, and are considered mature on the basis of length (Table 3).

A total of 49 hunting events were recorded from all sources for the period 18-26 July, including hunts conducted from Sadliarusiq and from Nadlua and Komukouri (Fig. 1). At Sadliarusiq shots were fired from a mean range of 132 m, and whales were struck in 42 events from a mean range of 108 m (Table 1). Of 42 whales struck, 21 were landed, eight were mortally wounded, two were superficially wounded and 11 were reported sunk/lost (Table 2). The landed catch of 21 narwhals was composed of 16 males, four females and one whale of unknown sex. All males were reportedly tusked, except one whose length was estimated at 244 cm. Two of the four females were examined after flensing, their lengths were estimated at 366 cm, suggesting maturity (Table 3).

On 26 July, our staff learned that the Pond Inlet HTA had temporarily suspended hunting since half of the narwhal quota had been filled. The remaining tags were distributed before hunting resumed on 01 August. Field staff had recorded 43 narwhals landed to that date (85% of the reported take).

Field staff accompanied narwhal hunters to camps in the Eclipse Sound/Navy Board Inlet area when hunting resumed on 01 August, and collected information on this active boat hunting stage of the open water hunt until 25 August. Twenty four hunting events were observed from which shots were fired at a mean range of 19 m; and whales were struck in 17 observed events from a mean range of 9 m (Table 1). Twenty-five narwhals were observed struck, of which 12 were landed, 10 were mortally wounded, two were superficially wounded and one was lost (Table 2). One of the 12 landed whales (a juvenile) was beached and harpooned, not shot. Of the remaining 11 landed whales, seven were mature tusked males, three were mature females and one was a tusked whale of unknown sex (Table 3).

Sixty-nine hunting events were recorded from all available sources in August, and shots were fired in all of these from a mean range of 17 m. Whales were struck in 62 observed events, from a mean range of 10 m (Table 1). Of 71 whales reported struck, 50 were landed, 12 were mortally wounded, four were superficially wounded and five were sunk/lost (Table 3). The landed catch consisted of 28 males, six females and 16 narwhals of unknown sex. Twenty mature males and one immature male were landed. The remaining seven landed males were not measured. One immature and five mature females were landed. Sixteen whales cannot be classified by sex or length, but most of these were likely tusked males as these animals seem to be the major target of open water hunts (Table 3).

Combined information for the entire open water hunt (July and August) appears in Table 1, but this data must be interpreted with caution as it represents two slightly different hunting techniques.

1983: Break-up occurred on 20-21 July in 1983, and between five and seven hunters participated in the early stage of open water hunting (from cliffs) at Sadliarusiq until 24 July. Two hunting events were observed, of which one was successful. One whale was struck and mortally wounded at a range of 50 m (Tables 1 and 2).

Information from the 1983 open water hunt in Pond Inlet is limited because DFO staff observed the open water hunt in Arctic Bay in August. Contract observer records from the August to October open water hunt in Eclipse Sound indicate that bad weather restricted hunting activity during the first two weeks of August. From 12 September to 04 October, 17 narwhals were struck, of which 16 were landed and one was sunk. Combined information from all sources for the Eclipse Sound open water hunt accounts for 18 whales struck, of which 16 were landed, one was mortally wounded and one was sunk (Table 2).

The total kill

Catch composition: In Table 4 we compare previously reported catch compositions to those observed in 1982 and 1983. Although some unclassified whales have been described as tusked or untusked; this information cannot be used to identify the sex since tusked whales of both

sexes occur (in 1982, 2/21 females reported landed were tusked). It may be safe to assume, however, that the majority of tusked whales reported landed are males.

The proportion of females landed at the floe edge in 1982 was 67%, an increase from 40% reported in 1979. Data from the 1977-1979 floe edge hunts suggest a progressive decline in the proportion of females landed. This increase may reflect either animal availability, or the 2-year lapse in harvest studies conducted in the area, both of which may have influenced hunter selection. In 1983 the floe edge catch was limited by the Pond Inlet HTA, and females composed only 14% of the total catch for this hunt phase.

Ice conditions severely restricted the ice crack hunt in 1982; only four whales (two females, one male, one unclassified) were reported landed. The landed catch in 1983 consisted of 10 males (53%) and two females (10%); the balance of the catch is unclassified. The 1983 ice crack catch data is consistent with past studies, which show a strong selection towards males during this phase of the harvest.

The 1982 open water hunt data also suggest a strong selection towards males, which is consistent with data collected in previous years. Males composed 62%, females 14%, and unclassified animals 24% of the landed catch. As indicated previously, records from this phase of the 1983 harvest are incomplete, and the catch composition cannot be described. The Pond Inlet HTA reported a landed catch of 105 narwhals for the entire 1983 harvest; however, we documented only 42 narwhals landed. We have assumed that the remaining 63 whales were landed during the open water hunt. It may be safe to suppose that the majority of both the outstanding 63 whales and the 16 unclassified whales reported landed were tusked males, as these seem to be the most actively pursued during open water hunts.

Catch distribution: The 1982 floe edge, ice crack and open water landed catch composed 19%, 4% and 76% of the total harvest respectively. However, the ice crack hunt is greatly dependent on local ice conditions, which were poor in 1982.

In 1983, we documented only the floe edge and ice crack hunts. Using all available information (and the landed total of 105 whales reported by the HTA) these hunts composed 7% and 18% of the total harvest for that year. The HTA's restriction of the 1983 floe edge catch to 10 narwhals reduced the proportion of the total harvest attributable to this hunt phase. The number of whales taken during the ice crack hunt reflects the good ice conditions encountered.

We calculated the open water proportion of the total harvest by subtracting the floe edge and ice crack catches from the landed total of 105 narwhals reported by the Pond Inlet HTA. By this method, 75% of the total harvest for 1983 was landed during the open water hunt. This is consistent with our 1982 observations, and with previously reported catch distributions (Table 5).

Although the proportions of narwhal landed in each hunt phase vary annually with environmental conditions and animal availability, the open water catch is the most significant, followed by the floe edge and ice crack hunts.

Loss rates: Previously reported loss rates are expressed as the ratio of narwhals killed and lost to the total number killed, in which the first term represents whales killed and sunk and those considered mortally wounded and lost (Finley et al. 1980; Finley and Miller 1982). Although this method produces a useful central estimate of hunting losses, the classification of mortally or superficially wounded animals requires an interpretive decision from the observer, which under some circumstances is difficult. Some animals deemed mortally wounded may live and conversely, some deemed superficially wounded may die. We report hunting losses in terms of the total number of narwhal struck, to compensate for the possibility of interpretive error in calculating total removals, and as a range rather than a single value. The lower limit represents the ratio of mortally wounded, sunk or lost narwhals to the total number struck, and the upper limit represents the ratio of all narwhals struck and not landed to the total number struck (Table 6). The reader should note that loss rates presented here are lower than those previously estimated, because the divisor is larger. The maximum loss rate is an inflated value, because many struck animals survive, as indicated by old bullet scars. The minimum loss rate is the only estimate of hunting losses for which we have substantive information.

Loss rates at the floe edge were very high in 1982, and 56% of the whales struck were lost. As a result, the Pond Inlet HTA limited the number of tags available in 1983 for this hunt phase. Loss rates observed in 1983 (27%) were approximately half those reported in 1982, suggesting that a local initiative in reducing hunting losses at the floe edge was successful.

The ice crack hunt was of short duration in 1982, and was hampered by poor weather and ice conditions. Although all reported hunts took place at Sadliarusiq, field staff were able to document only three, all of which resulted in lost whales. The loss rate of 56% calculated from all available information is likely a more accurate reflection of actual losses incurred. In 1983, only 10% of the whales observed struck were lost.

A loss rate of 42% was incurred during both phases of the open water hunt in 1982. Losses of 38% and 44% were calculated from observed cliff hunting (July) and boat hunting (August) components, respectively. In August 1983, one whale was observed mortally wounded and lost before field staff relocated to Arctic Bay.

Finley et al. (1980) calculated that 69% of the total kill at the 1978 Pond Inlet floe edge was lost. Losses at the ice crack hunt were not calculated, but were thought to be less than those evident at the floe edge. A loss rate of 25% of the total kill was applied to

the 1978 open water hunt, based on combined observations of the 1976-1977 open water hunt. Finley and Miller (1982) did not calculate loss rates for the 1979 narwhal hunt at Pond Inlet, but they thought that losses were reduced from those observed in 1978.

To compare our results with past studies (Finley et al. 1980; Finley and Miller 1982), we must express losses in terms of total number killed. Based on DFO observed hunting events at the floe edge in 1982, 71% of the narwhal killed were lost. This value is similar to losses reported by Finley et al. (1980) for the 1978 floe edge (69% of the total kill). In 1983, following local restriction of the number of tags available for the floe edge hunt, losses were reduced to 43% of the total number of narwhal killed.

Whales were not observed landed at the ice crack hunt in 1982. The loss rate calculated from all available information (56% of total kill) likely reflects the actual losses incurred during this hunt phase. Losses observed at the ice crack hunt in 1983 were 12% of the total kill.

The combined loss rate for both phases of the 1982 open water hunt was 48% of the total kill, almost double that estimated for 1978 (Finley et al. 1980). Losses incurred during each stage of the open water hunt were similar, 50% of the total kill was lost during ice dispersal in July and 48% of the total kill was lost during August. There is insufficient information to calculate observed losses for the 1983 open water hunt.

Estimated total kill: Calculation of the estimated total kill is perhaps more useful when interpreting harvest information from species such as narwhal, which are managed by quota. The 1979 narwhal harvest in Pond Inlet was described by Finley and Miller (1982), but since information on hunting losses was limited an estimate of the total kill could not be calculated. These authors applied the percentage of narwhal of each sex which they examined to the total number of tag returns to produce an estimate of the total landed catch. Finley et al. (1980) estimated the total kill during the 1978 Pond Inlet narwhal harvest by multiplying the total reported landed catch by the ratio (whales observed killed:whales observed landed). Calculation of this kill:landed estimator depends on knowledge of the outcome of hunting events in which whales are struck, and especially on observations of whales struck and landed. An added limitation of this method is the statistical bias associated with the estimator.

We applied the jackknife procedure (Efron and Gong 1983) to the observed kill:landed estimators from 1982 and 1983 to reduce the bias associated with them. Reduced-bias estimators (hereinafter referred to as revised estimators) can be calculated for each of the 1982 and 1983 floe edge hunts. Since whales were not observed landed during the 1982 ice crack and the 1983

open-water hunts, we pooled the two years of data for each. These pooled reduced-bias estimators were then applied to the total reported landed catch in individual years. Total kill estimates are rounded upwards to the nearest integer.

Our estimates of the total kill during 1982 and 1983 are presented in Table 7. From the 1982 harvest data, we estimate that 25 narwhal were killed at the floe edge, six were killed at the ice cracks, and 138 were killed during the open water hunt. The estimated total kill of 169 animals is considerably lower than that reported for 1978 (Finley et al. 1980). In 1983, an estimated 11 narwhals were killed at the floe edge, 29 were killed at the ice cracks, and 153 during the open water hunt. The total estimated kill of 193 animals is also lower than that reported for the 1978 harvest.

The comparison of our results with previous estimates requires identical revision of published data. The jackknife procedure can only be applied to information from the 1978 floe edge hunt (Finley et al. 1980), and results in a revised estimator of 2.68. When this reduced-bias estimator is applied to the reported landed catch of 59 animals, the estimated total kill at the floe edge in 1978 is reduced to 159 narwhal from 189. The 1978 data for the ice crack and open water hunts do not include the number of whales struck and lost, so the jackknife procedure cannot be used to reduce bias. We added our reduced-bias estimate of the floe edge loss to existing kill estimates for the ice crack and open water hunts provided by Finley et al. (1980), which reduces the total estimate from 312 to 282 narwhal killed during the 1978 harvest.

BIOLOGICAL SAMPLING

Morphometrics

Field staff examined 62 narwhals (20 females and 42 males) during the two-year study period, and measurements are available for most of these animals (Appendix 1). Incomplete records resulted from examination of partly flensed animals.

Descriptive statistics for body measurements were compiled using total length as an indicator of maturity (Finley et al. 1980; Finley and Miller 1979). Estimated measurements (three whales) and those of immature animals (three whales) were excluded from the calculations. Body measurements of adult females (>340 cm) are not significantly different between years. Descriptive statistics for the cumulative sample are presented in Table 8. In adult males, (>390 cm) total length was significantly greater in 1983 than in 1982 (448 cm vs 428 cm, $t=-2.78$, $df=35$, $p<.01$), but remaining body measurements are not significantly different between years (Table 9). A frequency distribution of total body length (20 cm intervals) for the combined harvest appears in Fig. 2.

Blubber thickness

Repeatable blubber thickness measurements were obtained mid-dorsally and mid-ventrally on the axillary circumference, and mid-laterally on the umbilical circumference (Table 10). The data show no significant correlation ($p < 0.05$) among blubber thickness measurements in males. Total body length and fluke width show weak, but statistically significant correlations to lateral blubber thickness ($r = 0.63$ and 0.65).

No correlation exists between any of the blubber measurements and time, which suggests a stable energy balance in male narwhal during the period of study. This observation is consistent with data presented by Finley and Gibb (1982), who noted no decrease in condition over time in male narwhal examined.

Reproduction

Males: Testes were measured from 21 narwhals killed in August of 1982, and from 12 narwhals killed in July of 1983 (Table 11).

The calculated estimate of testis volume shows some correlation to total body length in the combined sample ($r = 0.57$, $n = 28$) and in the 1982 data ($r = 0.70$, $n = 19$). Although the combined sample spans a two month period, there is no significant correlation between date of sampling and the calculated testis volume of male narwhal greater than 390 cm in length. Histological study (Hay 1984) has shown that neither mature nor maturing testis volume is dependent on time.

Females: Reproductive information is available for 16/24 females known landed in 1982 and for 2/3 landed females documented prior to August 1983 (Table 12). Four animals landed in 1982 and one landed in 1983 carried full term fetuses. Only three females examined in 1982 were newly pregnant and four carried term fetuses; yielding pregnancy rates of 19% and 25%. In 1983, the one pregnant female carried a term fetus. These values are considerably less than previously reported (Finley and Miller 1980; Hay 1984).

Near term fetuses were carried by lactating females from whose teats colostrum exuded or could be expressed, suggesting imminent parturition. The mean length of four such fetuses examined from 20 June to 20 July was 159 cm. Hay (1984) calculated a mean birth length of 161 cm at 01 August.

Four of the landed females were lactating, but not pregnant. Of these, one was accompanied by a male calf whose length was estimated at 8 ft (~240 cm). The mammary glands of this female were 5 cm thick and her milk was thick, green and opaque, suggesting that weaning had not yet begun. The mammary glands of two females were 4.8 and 6.0 cm thick respectively, suggesting that they may have been accompanied by nursing calves. The mammary glands of the remaining female were 3 cm thick, which may indicate recent weaning. Small amounts of a pale white, opaque fluid with a yellow-green tinge were present or could be expressed from the teats of these three females.

Feeding

Field staff examined a total of 47 narwhal stomachs over two years, of which 22 (47%) showed evidence of feeding. Although data from individual years illustrate isolated blocks of the study period, the cumulative sample is representative of the entire season (June - August). Food remains were observed in females throughout the summer months, typically in small amounts and often associated with a large volume of fluid, which is presumably sea water or blood. By contrast, the data suggest that males do not feed during the first three weeks of August.

In 1982, food items were observed in 7/11 adult female and 5/21 adult male narwhals. Documentation is unavailable for whales examined at the floe edge; only the presence/absence of food and approximate fluid volume was recorded. Unidentified fish and squid appeared to form the bulk of narwhal diet in late July and August, appearing in 24% and 27% of stomachs examined, respectively. Crustaceans (presumably Mysids) occurred in only 6% of stomachs examined, and their presence was noted only during the third week of July at the ice crack hunt.

In 1983, food items were observed in 1/2 females and 9/13 males examined during the floe edge and ice crack hunt phases. Fish and squid were the main prey species observed in 1983, occurring in 60% and 53% of stomachs examined, respectively. The remains of one Greenland halibut (*Rheinhardtius hippoglossoides*) was positively identified in the stomach of one male narwhal landed on 18 June. The egg case of a shark (likely *Somniosus macrocephalus*) or ray (*Hypotremata*) was noted in the stomach of this whale, and also in another male landed on 03 July. The sole female examined was pregnant and had been feeding on squid and fish.

Although the data presented here are qualitative, they can be compared to previous observations on narwhal diet in Eclipse Sound. In the 22 stomachs which gave evidence of feeding, fish remains and squid beaks were present throughout the study period and each occurred in 65% of the sample. However, the presence of squid beaks is not necessarily an indication of recent feeding. Results of our stomach examinations are consistent with the observations of Finley and Gibb (1982), who noted little or no feeding activity in narwhal during late summer. The presence of halibut and of Elasmobranch egg cases in stomachs examined at the floe edge during 1983 further illustrates the deep diving capability of male narwhal noted by these authors.

Tusk measurements

In 1982 field staff measured exposed length and basal circumference on the tusks of landed whales to which they had access, and in 1983 they measured total tusk length as well. In addition, they measured tagged tusks in the community of Pond Inlet, tusks available in hunting camps, and those on beached carcasses whenever possible (Appendix 1).

Two tusked females and one tusked juvenile were landed in 1982. One female was not measured, but the hunter estimated its' tusk to be 4 ft (=120 cm) long. The second female (385 cm total length) possessed a tusk 100 cm in exposed length. The juvenile male (267 cm total length) possessed a 5 cm tusk. Hay (1984) calculated a body length of 264 cm at tusk eruption for narwhal in Pond Inlet.

In total the exposed length of 41 narwhal tusks (40 males and one female) was recorded, of which 12 (29%) were broken. Eleven tusks were broken at lengths exceeding 120 cm, and one was broken off at its' base. All broken tusks recorded were on adult males. Silverman and Dunbar (1980) reported breakage in 40% (27/68) of all tusks examined, with a higher incidence in adult males. Hay (1984) observed breakage in 18% (13/73) of the tusks he examined, and noted a higher incidence of breakage in tusks exceeding 60 cm in length.

To examine relationships between body and tusk measurements we used data from known-length narwhal having intact tusks. Significant relationships are presented in Table 13. The relationship between exposed tusk length and total body length is plotted for the intact tusks of 27 male and one female narwhal in Fig. 3. The data are consistent with that of Hay (1984) and Silverman and Dunbar (1980), who describe accelerated tusk growth in adult male narwhal.

We combined the data from landed whales and from opportunistically examined tusks to examine relationships among tusk measurements alone. Significant correlations occur between basal circumference and total tusk length ($r=0.86$, $n=19$), between basal circumference and exposed tusk length ($r=0.71$, $n=39$), and between total and exposed tusk lengths ($r=0.85$, $n=18$).

SUMMARY AND CONCLUSIONS

- Narwhal hunting techniques observed in Pond Inlet remain virtually unchanged from those previously described for all phases of the harvest. We have separated the open water hunt into two phases: deep water hunting from cliffs in July, and active shallow water hunting from boats during the balance of the hunting season. The latter technique appears to be the most effective in reducing hunting losses.
- Landed catch composition at the 1982 floe edge was mainly females (67%), however, in 1983 the proportion of females in the floe edge landed catch was reduced to 14%. This reduction may reflect changed animal availability or increased hunter selection.
- The ice crack hunt in 1982 was minimal; only four whales were landed, of which two were female. In 1983 19 whales were landed, of which two (10%) were females and 10 (53%) were known males.
- The open water hunt in 1982 selected strongly for males (62% of the landed catch). Data for 1983 are minimal, but likely an equal or greater percentage of the harvest consisted of tusked males.
- The open water hunt accounts for most of the total annual harvest, followed by the floe edge and ice crack hunts. The latter two hunt phases vary in annual importance depending on local HTA restrictions and annual ice conditions.
- We report hunting losses as a range rather than a single value, and base our calculations on the total number of animals struck. Minimum loss rates are based on DFO observed events only. The floe edge and open water hunt phases resulted in loss rates of 56% and 42% of the total number struck in 1982. The ice crack hunt in 1982 was minimal due to poor ice conditions; the loss rate of 56% is calculated from all available information. In 1983, local HTA policy reduced floe edge losses to 27% of the total number struck. Ice crack losses in 1983 were 10% of the total number struck. There is insufficient data to calculate observed open water losses during 1983, information from all sources produces a loss rate of 11% of the total number struck.
- Expressed in terms of total kill, losses observed at the floe edge were 71% in 1982, similar to past estimates. Local HTA restrictions reduced observed losses to 43% of the total kill in 1983. Fifty-six percent of the total kill was lost during the 1982 ice crack hunt, but only 12% of the total kill was lost at the ice cracks in 1983. During both phases of the 1982 open water hunt, 48% of the total kill was lost, almost double that of past estimates. Losses during the deep and shallow water hunting phases were similar (50% and 48% respectively). There is insufficient information to calculate observed losses for the 1983 open-water hunt.
- We estimate the total kill in 1982 to be 169 narwhal and in 1983 to be 193 narwhal.
- Morphometric characteristics of harvested females are unchanged between years. Total length of males harvested in 1983 was greater than in 1982; other body measurements are not significantly different between years.
- Blubber thickness measurements are most reliably obtained mid-dorsally and mid-ventrally on the axillary circumference, and mid-laterally on the umbilical circumference. No significant correlation was observed among blubber thickness measurements. Lateral blubber thickness correlates weakly with total body length and fluke width. No correlation was found between any blubber thickness measurement and time in male narwhal, which is consistent with pre-

viously recorded observations (Finley and Gibb 1982).

11. Correlation of testis volume to total body length is statistically significant in 1982 and in the combined sample ($r=0.70$ and $r=0.57$, respectively). A statistically significant correlation is not apparent between testis volume and time, in mature male narwhal.
12. Of 18 females for which reproductive information is available, five carried term fetuses and three were in early pregnancy. The overall pregnancy rate of 0.17 calculated from our data is less than previously reported values (Finley and Miller 1982; Hay 1984). The mean length of four term fetuses examined from late June to late July was 159 cm.
13. Qualitative data collected from narwhal stomachs during this study suggest males do not feed during the first three weeks of August. No break in feeding activity was observed in females. Squid and unidentified fish remains were most commonly observed in narwhal stomachs.
14. Twenty nine percent of the narwhal tusks examined were broken, and all broken tusks were observed in adult males. The most significant correlations were between exposed tusk length and total body length ($r=0.75$), tusk circumference and axillary girth ($r=0.74$), tusk circumference and total body length ($r=0.73$), and total tusk length and umbilical girth ($r=0.82$). One 267 cm juvenile examined in this study possessed a tusk 5 cm in length, and two tusked females were observed.

ACKNOWLEDGMENTS

This study was initiated in 1982 under the direction of J.T. Strong. R.S. Walker supervised data collection during both years of study. The authors especially wish to thank Seeana Attagootak of Pond Inlet for his valuable assistance in data collection. We are grateful to the hunters of Pond Inlet for their cooperation and support. Seeglook Akeeagok (DFO, Frobisher Bay) provided field and logistical assistance during the study period. Keith Hay (formerly DFO, Atlantic Region) assisted with data collection in 1982, and his insights and advice are much appreciated. Student assistance was provided by L. Dueck, K. Rebizant and R. Sauvelet.

We thank M.C.S. Kingsley for statistical advice and assistance. R.W. Moshenko, M.M. Roberge and J.T. Strong suggested improvements to earlier drafts. M.C.S. Kingsley and P.R. Richard critically reviewed the final manuscript. The technical assistance of C. Catt and B. Hyman is greatly appreciated.

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Table 1. Firing ranges (metres) documented during the Pond Inlet narwhal harvest, 1982-1983.

Year	Hunt Phase	Source ¹	All Hunting Events				Events Where Whales Struck						
			Total No.	No. With Range Recorded	Mean	Std. Dev.	Min. Max.	Total No.	No. With Range Recorded	Mean	Std. Dev.	Min. Max.	
1982	Floe Edge	A	15	14	43	47	15-200	8	8	25	10	15-40	
		B	38	18	37	43	6-200	31	12	22	11	6-40	
	Ice Crack	A	6	3	56	42	175-100	3	1	18	0	18	
		B	12	5	35	41	3-100	9	3	8	8	3-18	
	Open Water	A	15	6	165	149	40-400	8	5	138	149	40-400	
	July	B	49	8	132	140	15-400	42	7	108	133	15-400	
	August	A	24	13	19	22	2-75	17	9	9	8	2-20	
		B	69	16	17	20	2-75	62	12	10	8	2-20	
	Total	A	39	19	65	106	2-400	25	14	55	105	2-400	
		B	118	24	56	96	2-400	104	19	46	91	2-400	
	1983	Floe Edge	A	19	18	17	8	5-38	11	10	13	6	5-25
			B	32	18	17	8	5-38	23	10	13	6	5-25
Ice Crack		A	14	6	18	11	5-30	9	3	8	3	5-10	
		B	29	7	17	11	5-30	24	4	9	2	5-10	
Open Water		A	2	2	65	21	50-80	1	1	50	0	50	
		B	18	2	65	21	50-80	17	1	50	0	50	

¹A = DF0 observed only.

B = from all available sources (DF0, observer records, hunter interview).

Table 2. Harvest analysis for each phase of the Pond Inlet narwhal hunt, 1982-1983.

Year	Hunt Phase	Source ¹	Whales Struck	Whales Landed	Struck & Lost ²		Total Kill
					MW	S/L	
1982	Floe Edge	A	9	2	4	1	7
		R	32	18	4	8	30
	Ice Crack	A	3	0	2	1	3
		R	9	4	2	3	9
	Open Water July	A	8	3	3	0	6
		R	42	21	8	11	40
	August	A	25	12	10	1	23
		R	71	50	12	5	67
	Sub-Total	A	33	15	13	1	29
		R	113	71	20	16	107
1983	Total	A	45	17	19	3	39
		R	154	93	26	27	147
	Floe Edge	A	11	4	2	1	7
		R	23	7	2	10	19
	Ice Crack	A	10	7	0	1	8
		R	25	19	0	3	22
	Open Water	A	1	0	1	0	1
		R	18	16	1	1	18
	Total	A	22	11	3	2	16
		R	66	42	3	14	59

¹A = DF0 observed only.

B = from all sources (DF0, observer records, hunter interview).

²MW = mortal wound.

SW = superficial wound.

S/L = sunk/lost.

Table 3. Observed and total reported landed catch composition from each phase of the Pond Inlet narwhal hunt, 1982-1983.

Year	Hunt Phase	Source ¹	Landed Males			Landed Females			Unrecorded Sex			Total Landed
			Adult	Immature	Total(%)	Adult	Immature	Total(%)	Tusked	Untusked	Total(%)	
1982	Floe Edge	A	-	-	0(0)	-	-	2(100)	-	-	0(0)	2
		B	1	1	2(11)	-	7	12(67)	3	-	4(22)	18
	Ice Crack	A	-	-	-	-	-	-	-	-	-	0
		B	1	-	1(25)	-	2	2(50)	-	-	1(25)	4
	Open Water ²	A	8	1	9(60)	-	-	5(33)	1	-	1(7)	15
		B	35	2	44(62)	7	2	10(14)	-	17	17(24)	71
1983	Floe Edge	A	4	-	4(100)	-	-	0	-	-	0	4
		B	3	1	6(86)	-	1	1(14)	-	-	0	7
	Ice Crack	A	6	-	6(86)	1	-	1(14)	-	-	0	7
		B	8	-	10(53)	2	-	2(10)	-	2	7(37)	19
	Open Water ²	A	-	-	-	-	-	-	-	-	-	0
		B	-	-	-	-	-	-	-	16	16(100)	16

¹A = DEO observed only.

B = compiled from all available sources.

²Represents cumulative open water hunt and reflects both hunting styles.

Table 4. Landed catch composition in each phase of the Pond Inlet narwhal hunt, 1977-1983.

Table 4. Landed catch composition in each phase of the Pond Inlet harrow hunt, 1977-1983

Year	Hunt Phase	Males			Females			Unclassified			Total Kill	
		Adult	Immature	Unknown Total(%)	Adult	Immature	Unknown Total(%)	Tusked	Untusked	Unknown Total(%)		
1977 ¹	Floe Edge	6	0	1	32	7	3	1	50	0	0	22
	Ice Crack	7	18	0	48	14	4	0	data unavailable	0	0	52
	Open Water											
1978 ¹	Floe Edge	12	15	0	46	23	4	1	47	0	0	59
	Ice Crack	40	4	1	80	8	1	1	18	0	0	56
	Open Water	11	6	1	50	1	0	0	3	0	17	36
1979 ²	Floe Edge	12	7	4	58	10	1	5	40	0	0	40
	Ice Crack	7	0	4	84	1	0	0	8	0	1	13
	Open Water	22	6	8	60	10	3	6	32	0	5	60
1982 ³	Floe Edge	1	1	0	11	5	0	7	67	3	0	18
	Ice Crack	1	0	0	25	0	0	2	50	1	0	4
	Open Water	35	2	7	62	7	1	2	14	0	17	71
1983 ³	Floe Edge	5	1	0	86	0	0	1	14	0	0	7
	Ice Crack	8	0	2	53	2	0	0	10	0	2	19
	Open Water	0	0	0	0	0	0	0	0	0	16	16

¹Finley et al. (1980). Data from 1977 do not represent the total catch.²Finley and Miller (1982).³Compiled from all available sources (DFO, observer records, hunter interview).

Table 5. Proportion of landed catch attributed to each phase of the Pond Inlet narwhal harvest, 1977-1983.

Year	Source	Hunt Phase			Total
		Floe Edge	Ice Crack	Open Water	
1977	Finley et al. (1980)	22(30%)	- ¹	52(70%) ²	74 ²
1978	Finley et al. (1980)	59(39%)	56(37%)	36(24%)	151
1979	Finley & Miller (1979)	40(26%)	13(11%)	59(53%)	112
1982	This study ³	18(19%)	4(4%)	71(76%)	93
1983	This study ³	7(7%)	19(18%)	79(75%)	105

¹Ice crack hunt not conducted.²Incomplete total.³For 1982, documented kills from all sources are used.

In 1983, HTA records list a landed catch of 105 narwhals. The 63 undocumented kills are attributed to the open water hunt phase.

Table 6. Loss rates incurred during all phases of the Pond Inlet narwhal harvest, 1982-1983.

Year	Hunt Phase	Source ¹	Total Whales		Loss Rate (%) ²	
			Struck	Landed	Minimum	Maximum
1982	Floe Edge	A	9	2	5/9 (56%)	7/9 (78%)
		B	32	18	12/32(38%)	14/32(44%)
	Ice Crack	A	3	0	3/3 (100%)	3/3(100%)
		B	9	4	5/9 (56%)	5/9 (56%)
	Open Water (total)	A	33	15	14/33(42%)	18/33(55%)
		B	112	71	36/113(32%)	42/113(37%)
1983	Floe Edge	A	11	4	3/11(27%)	7/11(64%)
		B	23	7	12/23(52%)	16/23(70%)
	Ice Crack	A	10	7	1/10(10%)	3/10(30%)
		B	25	19	3/25(12%)	6/25(24%)
	Open Water (total)	A	1	0	1/1(100%)	1/1(100%)
		B	18	16	2/18(11%)	2/18(11%)

¹A = DFO observed hunts only.

B = information compiled from all sources.

²Minimum loss = $\frac{(\# \text{ mortally wounded \& lost}) + (\# \text{ sunk/lost})}{\text{total number struck}}$ Maximum loss = $\frac{\text{total struck \& not landed, ie. including superficially wounded}}{\text{total number struck}}$

Table 7. Estimated total kill, by hunt phase and year, for the Pond Inlet narwhal harvest, 1982-1983.

Year	Hunt Phase	Observed Struck	Observed Landed	Observed Struck & Lost ¹			Observed Total Kill	Observed Lost (%)	Kill:Landed Estimator	Reduced-bias ² Kill:Landed Estimator	Total Recorded Landed	Estimated Total Kill
				MW	SW	S/L						
1982	Floe Edge	9	2	4	2	1	7	5(71%)	3.50	1.36	18	25
	Ice Crack	3	0	2	0	1	3	3(100%)	-	1.48	4	6
	Open Water	33	15	13	4	1	29	14(48%)	1.93	1.93	71	138
	TOTAL	45	17	19	6	3	39	22(56%)			93	169
1983	Floe Edge	11	4	2	4	1	7	3(43%)	1.75	1.54	7	11
	Ice Crack	10	7	0	2	1	8	1(13%)	1.14	1.48	19	29
	Open Water	1	0	1	0	0	1	1(100%)	-	1.93	79	153
	TOTAL	22	11	3	6	2	16	5(31%)			105	193

¹MW = mortal wound.

SW = superficial wound.

S/L = sunk/lost.

²Calculated by applying the jackknife procedure (Efron and Gong 1983).

Table 8. Descriptive statistics for adult female narwhal measured (cm) in Pond Inlet, NWT, in 1982 and 1983.

Measurement	N	Mean	Mean Standard Error	Standard Deviation	Range
Total Length	17	388.77	5.23	21.57	348-420
Fluke Width	16	92.88	2.05	8.21	83-108
Axillary Girth	12	225.83	6.37	22.07	181-258
Umbilical Girth	12	244.42	7.40	25.60	215-294
Flipper Length 1 ¹	16	38.75	0.79	3.15	33-43
Flipper Length 2 ¹	13	34.70	0.80	2.87	31-40
Flipper Width	13	18.15	0.45	1.63	16-21

¹Flipper Length 1 = Anterior origin to tip
 Flipper Length 2 = Axilla to tip

Table 9. Descriptive statistics for adult male narwhal measured (cm) in Pond Inlet, NWT, in 1982 and 1983.

Measurement		N	Mean	Mean Standard Error	Standard Deviation	Range
Total Length	1982	24	428.50	3.80	18.64	390-475
	1983	13	448.38	6.77	24.39	400-486
Fluke Width	(cum)	36	106.94	1.37	8.19	87-121
Axillary Girth	(cum)	27	259.70	3.38	17.56	228-296
Umbilical Girth	(cum)	34	281.50	3.44	20.03	234-316
Flipper Length 1 ¹	(cum)	34	41.71	1.35	7.85	37-85
Flipper Length 2 ¹	(cum)	32	36.25	0.85	4.83	32-60
Flipper Width	(cum)	32	21.19	0.24	1.38	18-23

¹Flipper Length 1 = Anterior origin to tip
 Flipper Length 2 = Axilla to tip

Table 10. Skin and blubber thicknesses (cm) at three body locations on narwhal harvested in 1983 at Pond Inlet, NWT.

Sample	Sex	Total Length	Dorsal Axillary		Ventral Axillary		Lateral Umbilical	
			Skin	Blubber	Skin	Blubber	Skin	Blubber
PI83-01	M	401	1.0	6.0	2.0	8.0	1.5	7.0
PI83-03	M	424	1.0	5.1	1.3	7.2	1.4	6.6
PI83-04	M	486	0.9	7.6	1.9	11.4	1.2	8.3
PI83-05	M	462	1.5	7.5	2.0	11.9	1.3	7.7
PI83-06	M	457	1.6	8.9	2.4	8.2	1.7	9.1
PI83-08	M	460	.	.	0.9	7.0	1.5	7.2
PI83-12	M	443	1.5	6.5	2.0	12.5	1.0	8.0
PI83-13	F	374	2.0	10.0	1.5	7.5	1.5	5.5
PI83-15	M	460	1.5	8.5	2.0	10.0	1.5	6.5
PI83-100	M	471	1.5	6.0	1.8	7.7	1.5	7.0
PI83-101	M	439	1.1	7.5	2.1	7.5	1.5	6.5
PI83-14F	M	160	1.1	2.5	1.0	3.5	0.7	2.7

Table 11. Reproductive data from male narwhal examined in Pond Inlet, NWT. in 1982 and 1983.

Sample	Date	Total Length (cm)	Testis Length (cm)	Testis Width (cm)	Testis Height (cm)	Testis Weight (kg)	Testis Volume (ml)
PI82-13	04AUG82	439	21.0	10.2	4.6	.	985
PI82-14	04AUG82	440	20.5	9.9	4.9	.	994
PI82-15	04AUG82	.	20.3	9.6	4.9	.	955
PI82-16	04AUG82	475	22.0	9.9	4.9	.	1067
PI82-18	08AUG82	409	18.0	8.9	4.3	.	689
PI82-20	11AUG82	427	19.0	9.5	4.1	.	740
PI82-21	11AUG82	430	18.0	9.6	3.9	.	674
PI82-22	12AUG82	417	19.5	9.5	4.0	.	741
PI82-23	12AUG82	424	17.5	7.5	3.6	.	473
PI82-24	17AUG82	404	16.5	9.0	3.7	.	549
PI82-25	17AUG82	419	19.0	10.0	3.8	.	722
PI82-34	20AUG82	.	7.4	2.9	1.4	.	30
PI82-36	21AUG82	423	16.4	8.6	3.8	.	536
PI82-61	22AUG82	445	19.0	9.6	4.5	.	821
PI82-62	22AUG82	395	17.7	8.5	3.5	.	527
PI82-63	22AUG82	421	19.0	8.1	3.5	.	539
PI82-64	22AUG82	428	18.5	8.8	3.0	.	488
PI82-65	22AUG82	425	15.5	7.7	4.0	.	477
PI82-27	23AUG82	442	18.5	9.3	4.4	.	757
PI82-28	23AUG82	425	18.5	9.6	4.2	.	746
PI82-38	28AUG82	447	23.0	10.0	5.5	.	1265
PI83-04	30JUN83	486	23.0	11.0	4.0	1.19	1012
PI83-05	03JUL83	462	17.5	9.0	5.0	0.86	788
PI83-06	03JUL83	457	18.5	10.0	4.5	1.00	833
PI83-07	11JUL83	412	.	8.3	4.7	0.82	.
PI83-08	11JUL83	460	18.3	9.4	3.4	0.92	585
PI83-09	11JUL83	449	.	9.3	3.8	1.04	.
PI83-10	11JUL83	466	22.5	13.0	4.9	1.29	1433
PI83-12	12JUL83	443	19.0	8.9	3.1	0.90	524
PI83-15	15JUL83	460	18.0	9.0	4.7	0.86	761
PI83-100	16JUL83	471	19.0	8.5	4.8	0.93	775
PI83-101	16JUL83	439	21.0	9.5	5.4	0.94	1077
PI83-14F	13JUL83	160	4.5	1.9	1.3	0.09	11

Table 12. Reproductive information for female narwhal examined in Pond Inlet, NWT, 1982-1983.

Sample	Date	Location	Total Length (cm)	Pregnant: Fetus		Ovary (L/R) ¹			Mammary Gland Thickness (cm)	Lactating
				Sex	Size (cm)	CL	CA	Follicles		
P18201	02 June	Floe Edge	401	.	.					unknown
03	05 June	Floe Edge	348	.	.					unknown
06	09 June	Floe Edge	409	.	.					no
09	16 June	Floe Edge	382	.	.					no
40	20 June	Floe Edge	396	Unknown	unknown					yes
44	20 June	Floe Edge	.	F	162					unknown
xx1	20 June	Floe Edge	.	F	155					unknown
41	20 June	Floe Edge	.	Unknown	"term"					unknown
47	21 June	Floe Edge	394	.	.					no
48	29 June	Floe Edge	420	.	.					no
50	29 June	Floe Edge	366	.	.					no
53	03 July	Floe Edge	357	Unknown	"small"					no
54	17 July	Egukjuak	.	Unknown	"small"					no
33	17 July	Sadliiarusi	401	.	.					no
35	20 July	Sadliiarusi	366E	.	.					yes
10	20 July	Sadliiarusi	366E	F	159	no (L)	3(R)	"a few"	5.0	yes
11	02 August	Komukouri	375	.	.	0	2-3(L)	.	4.5	yes
19f	02 August	Komukouri	391	.	.	0	0	.	3.0	yes
26	08 August	Tremblay Sd	385	.	.	.	.	.	6.0	yes
31	17 August	Kaunuk	417	.	.	.	.	.	4.8	yes
32	25 August	Saatut	373	M	"1st yr"	.	0	.	1.9	no
P18311	25 August	Saatut	286	.	.	(L)	.	.	.	no
13	11 July	Sadliiarusi	420	.	.	.	.	.	.	no
	11 July	Sadliiarusi	374	M	160	(L)	0	.	3.7	yes

†-tusked animal.

E=estimated.

¹CL = corpus luteum.

CA = corpus albicans.

Table 13. Significant among body and intact tusk measurements from known length narwhal samples in Pond Inlet, NWT, 1982-1983.

Dependent Variable	Independent Variable	Correlation Coefficient (r)	p	n
Tusk Basal Circumference	Axillary Girth	0.74	0.0010	16
	Body Length	0.73	0.0001	25
	Umbilical Girth	0.69	0.0004	22
	Fluke Width	0.63	0.0008	25
	Tusk Exposed Length	0.61	0.0011	25
Tusk Total Length	Umbilical Girth	0.82	0.0438	6
Tusk Exposed Length	Fluke Width	0.78	0.0001	27
	Body Length	0.75	0.0001	28
	Umbilical Girth	0.60	0.0026	23

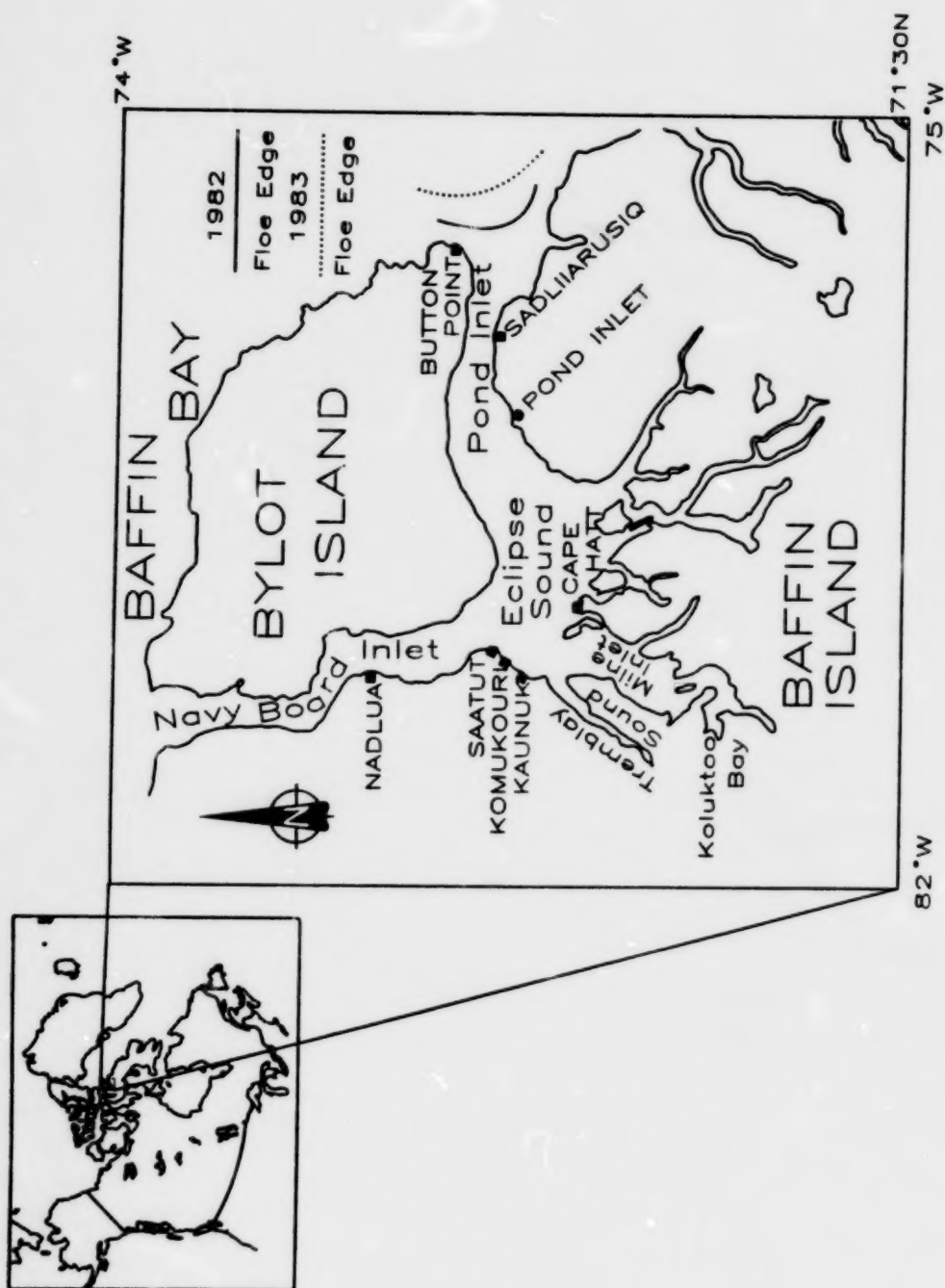


Fig. 1. The Pond Inlet study area and seasonal camp locations.

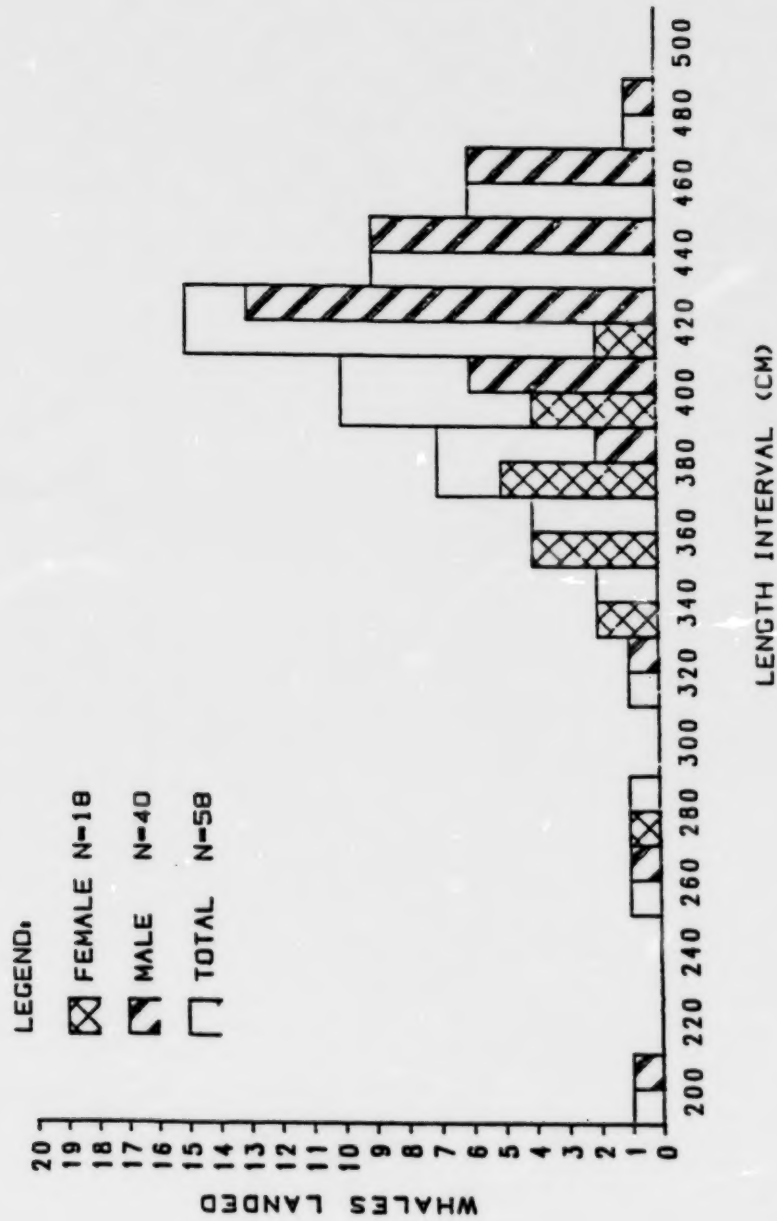


Fig. 2. Length-frequencies of narwhal landed in Pond Inlet, 1982-1983.

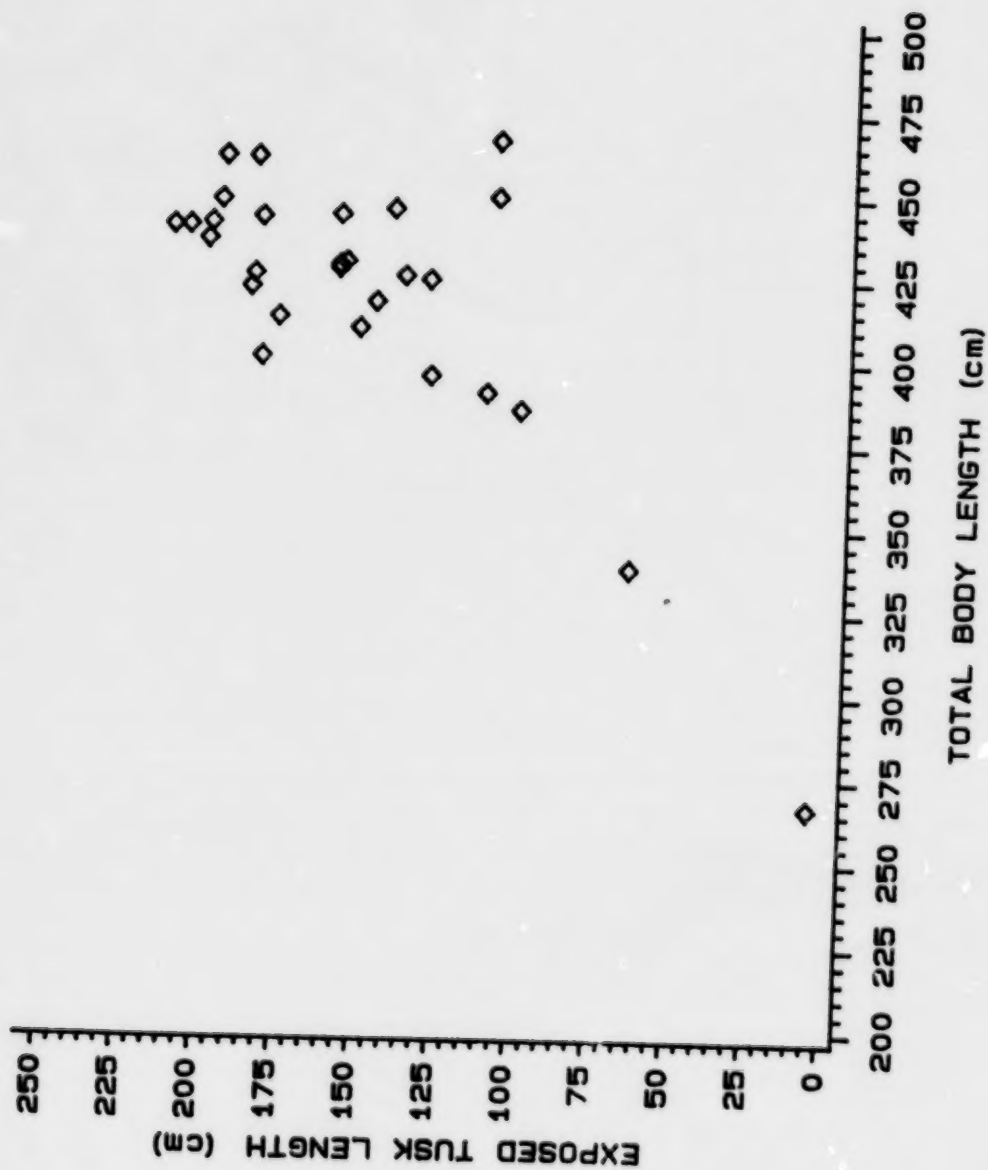


Fig. 3. Relationship between exposed tusk length and total body length in Pond Inlet narwhal, 1982-1983.

APPENDIX I

Measurements obtained from landed narwhal, 1982-1983

Table A1.1. Morphometric data (cm) obtained from post-natal narwhals in Pond Inlet, NWT, in 1982.

Sample	Date	Sex	Total Length	Fluke Width	Girth At Axilla	Girth At Umbilicus	Flipper Ant To Tip	Flipper Axilla To Tip	Flipper Maximum Width	Tusk Exposed Length	Tusk Total Length	Tusk Basal Circumf.	Tusk Condition
P182-1	02JUN82	F	401	85	.	.	36	.	.	.	.	.	.
P182-3	05JUN82	F	348	83	.	.	33	.	.	.	.	.	.
P182-6	09JUN82	F	409	99	.	.	36	.	.	.	.	.	.
P182-8	16JUN82	F	382	90	.	232	43	33	17	.	.	.	.
P182-10	02AUG82	F	375	89	218	226	43	37	18	.	.	.	.
P182-11	02AUG82	F	391	86	204	218	39	33	18	.	.	.	.
P182-19	08AUG82	F	385	84	236	238	38	31	17	100	.	12.5	.
P182-26	17AUG82	F	417	96	223	224	40	38	19	.	.	.	.
P182-31	25AUG82	F	373	88	213	224	42	37	17	.	.	.	.
P182-32	25AUG82	F	286	63	178	182	32	14	.	.	.	.	.
P182-33	20JUL82	F	366E	.	.	.	.	.	.	.	.	.	.
P182-35	20JUL82	F	366E	.	.	.	.	.	.	.	.	.	.
P182-40	20JUN82	F	396	94	241	294	40	34	18	.	.	.	.
P182-41	21JUN82	F	394	105	256	269	43	37	20	.	.	.	.
P182-47	30JUN82	F	420	105	244	256	40	33	21	.	.	.	.
P182-48	29JUN82	F	366	99	214	225	38	31	17	.	.	.	.
P182-50	03JUL82	F	357	85	181	215	36	32	17	.	.	.	.
P182-54	17JUL82	F	401	.	.	.	.	.	.	.	.	.	.
P182-2	02JUN82	M	390	99	.	.	41	.	.	111	.	14.6	.
P182-4	07JUN82	M	338	79	.	.	33	.	.	64	.	.	.
P182-5	08JUN82	M	267	56	.	.	25	.	.	5	.	.	.
P182-7	09JUN82	M	429	103	.	.	38	.	.	157	.	19.7	.
P182-12	02AUG82	M	205	52	.	140	27	22	12	.	.	.	.
P182-13	04AUG82	M	439	107	252	286	40	33	23	212	.	21.0	.
P182-14	04AUG82	M	440	106	.	300	39	35	22	200	.	22.0	Broken
P182-15	04AUG82	M	.	.	.	.	43	34	21	204	.	22.5	Broken
P182-16	04AUG82	M	475	110	.	316	41	36	21	135	.	24.2	Broken
P182-18	08AUG82	M	409	109	244	274	39	35	22	152	.	17.0	Broken
P182-20	11AUG82	M	427	103	228	250	40	35	21	159	.	17.5	Broken
P182-21	11AUG82	M	430	112	241	256	.	35	21	144	.	16.0	Broken
P182-22	12AUG82	M	417	107	254	270	39	34	20	147	.	17.0	Broken
P182-23	12AUG82	M	424	105	277	288	40	33	20	151	.	16.3	Broken
P182-24	17AUG82	M	404	87	250	263	37	35	21	135	.	16.3	Broken
P182-25	17AUG82	M	419	115	259	258	39	36	22	.	.	22.0	Broken
P182-27	23AUG82	M	442	120	255	278	44	37	22	184	.	22.5	Broken
P182-28	23AUG82	M	425	107	246	281	41	33	23	186	.	19.0	Broken
P182-29	25AUG82	M	435	117	264	302	41	36	22	201	.	24.0	Broken
P182-30	25AUG82	M	441	108	264	282	41	35	21	147	.	21.5	Broken
P182-34	20JUL82	M	244E	.	.	.	.	.	.	10	.	.	.
P182-36	21JUL82	M	423	98	251	260	39	33	20	120	.	18.9	Broken
P182-38	26JUL82	M	447	.	291	302	37	33	19	197	.	.	Broken
P182-52	10JUL82	M	454	112	264	264	42	38	23	186	.	22.2	Broken
P182-61	22AUG82	M	445	107	.	268	.	.	.	142	.	18.5	.
P182-62	22AUG82	M	395	93	.	234	42	35	19	129	.	18.3	.
P182-63	22AUG82	M	421	95	.	270	39	35	21	187	.	22.5	.
P182-64	22AUG82	M	428	104	.	288	40	33	22	159	.	21.4	.
P182-65	22AUG82	M	425	98	.	304	40	35	19	138	.	18.0	.

Table A1.2. Morphometric data (cm) obtained from post-natal narwhal in Pond Inlet, NWT. in 1983.

Sample	Date	Sex	Total Length	Fluke Width	Girth At Axilla	Girth At Umbilicus	Flipper Ant Origin To Tip	Flipper Axilla To Tip	Flipper Maximum Width	Tusk Exposed Length	Tusk Total Length	Tusk Basal Circumf.	Tusk Condition
PI83-11	11JUL83	F	420	108	254	266	39	35	21	.	.	.	.
PI83-13	12JUL83	F	374	90	224	270	34	40	16	.	.	19.5	.
PI83-1	16JUN83	M	400	108	257	288	85	60	21	183	165	19.5	Broken
PI83-3	20JUN83	M	424	93	233	243	44	37	19	130	165	23.9	Broken
PI83-4	30JUN83	M	486	121	286	312	43	40	22	146	215	22.0	Broken
PI83-5	03JUL83	M	462	119	270	284	42	38	22	175	214	25.5	Broken
PI83-6	03JUL83	M	457	113	296	302	39	38	22	172	218	22.8	Broken
PI83-7	11JUL83	M	412	102	266	288	39	33	21	196	238	25.5	Broken
PI83-8	11JUL83	M	460	121	294	312	40	36	22	109	223	23.0	Broken
PI83-9	11JUL83	M	449	103	261	290	40	32	20	109	223	23.0	Broken
PI83-10	11JUL83	M	466	118	273	273	43	35	18	159	201	19.0	Broken
PI83-12	12JUL83	M	443	106	246	302	41	40	23	186	238	25.2	Broken
PI83-15	15JUL83	M	460	107	264	289	42	39	23	201	244	26.0	Broken
PI83-100	16JUL83	M	471	107	258	289	42	37	22	207	248	20.6	Broken
PI83-101	16JUL83	M	439	110	241	278	42	37	22	207	248	20.6	Broken

Appendix A1.3. Tusk measurements (cm) obtained by opportunistic examination of beached carcasses, tagged tusks, and tusks available during camp visits.

Year	Location	Body Length	Sex	Tusk Total Length	Tusk Erupted Length	Rasal Circumf.	Comments
1982	Sedliarsiq	450	M	170	128	22	Reached carcass. Tusk with old break well back from tip.
	vic. Kaunuk	.	.	171	137	14	
	Floe Edge	.	.	120	90	10	
	Floe Edge	.	.	198	163	22	
	.	.	M	211	171	22	
	Low Pt.	.	M	.	190	26	Good condition.
	Low Pt.	.	M	205	167	18	
	Low Pt.	.	M	172	138	16	
	Low Pt.	.	M	136	104	13	
	Komukouri	.	.	210	173	20	Tip broken. Diameter at tip = 7.5 cm. Prominent secondary spiral.
	The Bay	.	.	236	197	24	Tagged for May. Tip slightly broken.
	Kaunuk	.	.	225	192	19	Approximate weight 6 kg
	Kaunuk	.	.	220	182	20	Approximate weight 6 kg
	Kaunuk	.	.	176	142	18	Approximate weight 4 kg
	Nadlua	.	.	.	118	14	Still in skull.
	Nadlua	.	.	187	152	18	
	.	.	.	196	154	19	Slight secondary spiral.
	.	.	.	150	116	16	Slight secondary spiral. Broken tip. Mameter at tip 2.3 cm.
1983	Arctic Bay	.	.	.	142(L) 131(R)	20(L) 19(R)	Double tusked.
	Arctic Bay	.	M	62	43	10	